Effective discrimination of protective devices

In the event of a fault occurring on an electrical installation only the protective device nearest to the fault should operate,leaving other healthy circuits unaffected. A circuit designed in this way would be considered to have effective discrimination. Effective discrimination can be achieved by graded protection since the speed of operation of the protective device increases as the rating decreases. This can be seen in Fig1 .A fault current of 200 A will cause a 15A semi-enclosed fuse to operate in about0.1 seconds, a 30 A semi-enclosed fuse in about 0.4 seconds and a 60 A semi-enclosed fuse in about 5.0 seconds. If a circuit is arranged as shown in Fig.2 and a fault occurs on the appliance, effective discrimination will be achieved because the 15 A fuse will operate more quickly than the other protective devices if they were all semi-enclosed type fuses with the characteristics shown in Fig. 1 .Security of supply, and therefore effective discrimination, is an important consideration for an electrical designer and is also a requirement of the Regulations.

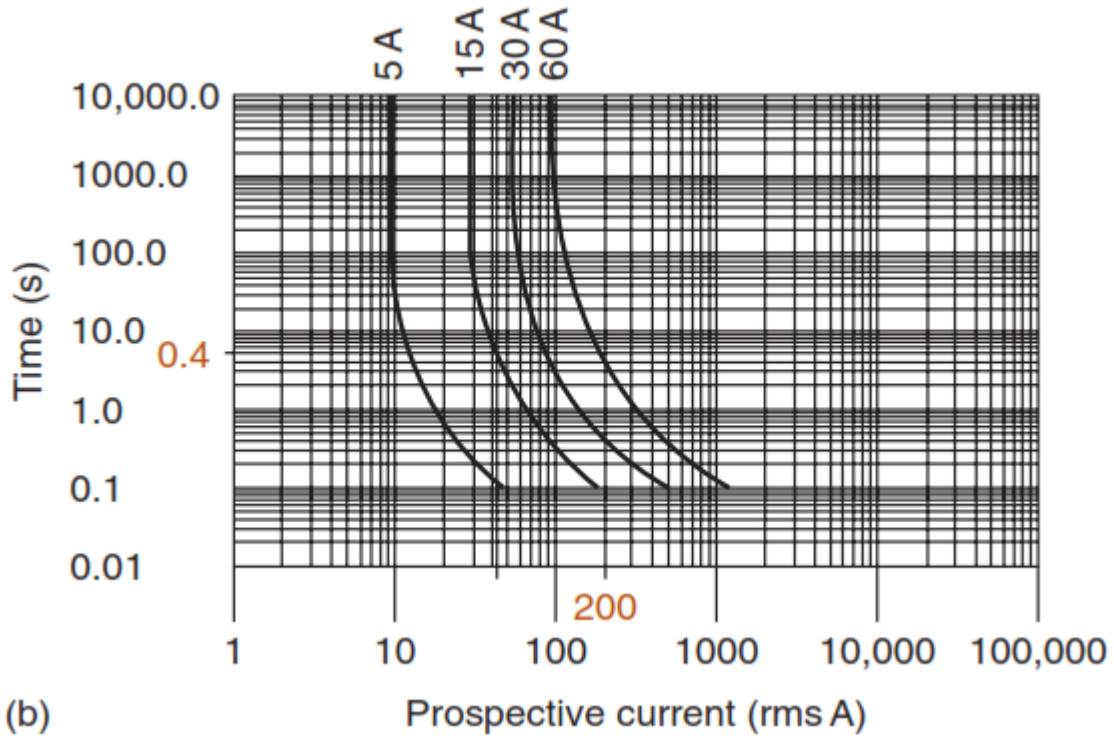


FIGURE 1 Time/current characteristics of semi-enclosed fuse to BS 3036.

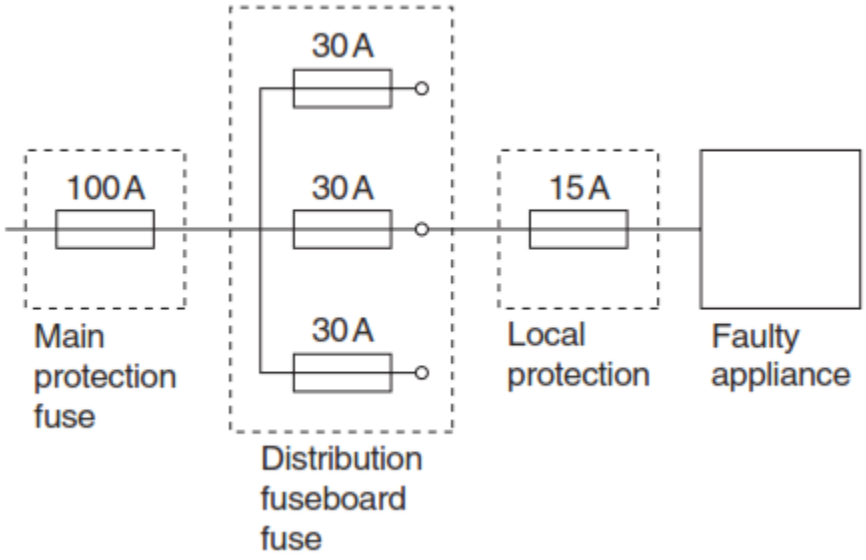


FIGURE 2 Effective discrimination achieved by graded protection.

The basic functions of LV switchgear

The role of switchgear is:

- ***Electrical protection***
- ***Safe isolation from live parts***
- ***Local or remote switching***

Electrical protection at low voltage is (apart from fuses) normally incorporated in circuit-breakers, in the form of thermal-magnetic devices and/or residual-current operated tripping devices .
In addition to those functions shown in Figure 1, other functions, namely:

- Over-voltage protection
- Under-voltage protection

are provided by specific devices, relays associated with contactors, remotely controlled circuit-breakers, and with combined circuit-breaker/isolators… and so on)
The aim is to avoid or to limit the destructive or dangerous consequences of excessive (short-circuit) currents, or those due to overloading and insulation failure, and to separate the defective circuit from the rest of the installation.
A distinction is made between the protections of:

- The elements of the installation (cables, wires, switchgear…)
- Persons and animals
- Equipment and appliances supplied from the installation

Types of switching devices

Device	Application	Comments
Isolator or disconnector	Performs the function of isolation	Not designed to be operated on load. Isolation can also be achieved by the removal of fuses, pulling plugs, etc.
Functional switch	Any situation where a load needs to be frequently operated, i.e. light switches, switches on socket outlets, etc.	A functional switch could be used as a means of isolation, i.e. a one-way light switch provides isolation for lamp replacement provided the switch is under the control of the person changing the lamp.
Switch-fuse	At the origin of an installation or controlling sub-mains or final circuits	These can perform the function of isolation while housing the circuit protective devices.
Fuse-switch	As for switch-fuse	Mainly used for higher current ratings and have their fuses as part of the moving switch blades.
Switch disconnector	Main switch on consumer units and distribution fuse boards	These are ON LOAD devices but can still perform the function of isolation.

The protection of circuits

- Against overload; a condition of excessive current being drawn from a healthy (unfaulted) installation
- Against short-circuit currents due to complete failure of insulation between conductors of different phases or (in TN systems) between a phase and neutral (or PE) conductor Protection in these cases is provided either by fuses or circuit-breaker, in the distribution board at the origin of the final circuit (i.e. the circuit to which the load is connected.

The protection of persons

- Against insulation failures. According to the system of earthing for the installation (TN, TT or IT) the protection will be provided by fuses or circuit-breakers, residual current devices, and/or permanent monitoring of the insulation resistance of the installation to earth.

The protection of electric motors

- Against overheating, due, for example, to long term overloading, stalled rotor

single-phasing, etc. Thermal relays, specially designed to match the particular characteristics of motors are used. Such relays may, if required, also protect the motor-circuit cable against overload. Short-circuit protection is provided either by type aM fuses or by a circuit-breaker from which the thermal (overload) protective element has been removed, or otherwise made inoperative.

2. Elementary switching devices

Disconnector (or isolator) (see **Fig. 3**)

This switch is a manually-operated, lockable, two-position device (open/closed) which provides safe isolation of a circuit when locked in the open position. Its characteristics are defined in IEC 60947-3. A disconnector is not designed to make or to break current and no rated values for these functions are given in standards. It must, however, be capable of withstanding the passage of short-circuit currents and is assigned a rated short-time withstand capability, generally for 1 second, unless otherwise agreed between user and manufacturer. This capability is normally more than adequate for longer periods of (lower-valued) operational overcurrents, such as those of motor-starting. Standardized mechanical-endurance, overvoltage, and leakage-current tests, must also be satisfied.

Fig. 3 : Symbol for a disconnector (or isolator)

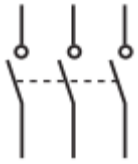
Load-breaking switch (see **Fig. 4**)

This control switch is generally operated manually (but is sometimes provided with electrical tripping for operator convenience) and is a non-automatic two-position device (open/closed).
It is used to close and open loaded circuits under normal unfaulted circuit conditions It does not consequently, provide any protection for the circuit it controls.
The utilization categories referred to in **Figure 4** do not apply to an equipment normally used to start, accelerate and/or stop individual motors.

Example
A 100 A load-break switch of category AC-23 (inductive load) must be able:

- To make a current of 10 I_n (= 1,000 A) at a power factor of 0.35 lagging
- To break a current of 8 I_n (= 800 A) at a power factor of 0.45 lagging
- To withstand short duration short-circuit currents when closed

Fig. 4 : Symbol for a load-break switch



Remote control switch (see **Fig. 5**)

This device is extensively used in the control of lighting circuits where the depression of a pushbutton (at a remote control position) will open an already-closed switch or close an opened switch in a bistable sequence.
Typical applications are:

- Two-way switching on stairways of large buildings
- Stage-lighting schemes
- Factory illumination, etc.

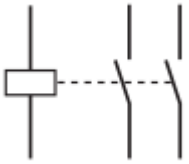


Fig.5

It is also called teleruture switch.

Fig. 5 : Symbol for a bistable remote control switch

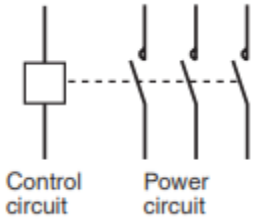
Contactor (see **Fig. 6**)

The contactor is a solenoid-operated switching device which is generally held closed by (a reduced) current through the closing solenoid (although various mechanically-latched types exist for specific duties). Contactors are designed to carry out numerous close/open cycles and are commonly controlled remotely by on-off pushbuttons. The large number of repetitive operating cycles is standardized in table VIII of IEC 60947-4-1 by:

- The operating duration: 8 hours; uninterrupted; intermittent; temporary of 3, 10, 30, 60 and 90 minutes
- Utilization category: for example, a contactor of category AC3 can be used for the starting and stopping of a cage motor
- The start-stop cycles (1 to 1,200 cyles per hour)
- Mechanical endurance (number of off-load manœuvres)
- Electrical endurance (number of on-load manœuvres)
- A rated current making and breaking performance according to the category of utilization concerned

Example:
A 150 A contactor of category AC3 must have a minimum current-breaking capability of 8 I_n (= 1,200 A) and a minimum current-making rating of 10 I_n (= 1,500 A) at a power factor (lagging) of 0.35.

Fig. 6 : Symbol for a contactor



3. Protection of people

Where utility power supply systems and consumers' installations form a TT earthed system, the governing standards impose the use of RCDs to ensure the protection of persons

On TT earthed systems, the protection of persons is ensured by the following measures:

- Protection against indirect contact hazards by RCDs (see **Fig. 7**) of medium sensitivity (300 mA) at the origin of the installation (incorporated in the incoming supply circuit-breaker or, on the incoming feed to the distribution board). This measure is associated with a consumer installed earth electrode to which must be connected the protective earth conductor (PE) from the exposed conductive parts of all class I insulated appliances and equipment, as well as those from the earthing pins of all socket outlets.
- When the CB at the origin of an installation has no RCD protection, the protection of persons shall be ensured by class II level of insulation on all circuits upstream of the first RCDs. In the case where the distribution board is metallic, care shall be taken that all live parts are double insulated (supplementary clearances or insulation, use of covers, etc.) and wiring reliably fixed.
- Obligatory protection by 30 mA sensitive RCDs of socket outlet circuits, and circuits feeding bathroom, laundry rooms, and so on .

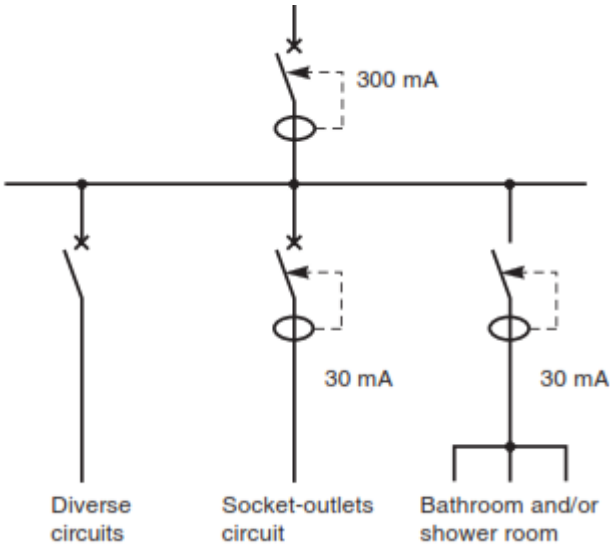
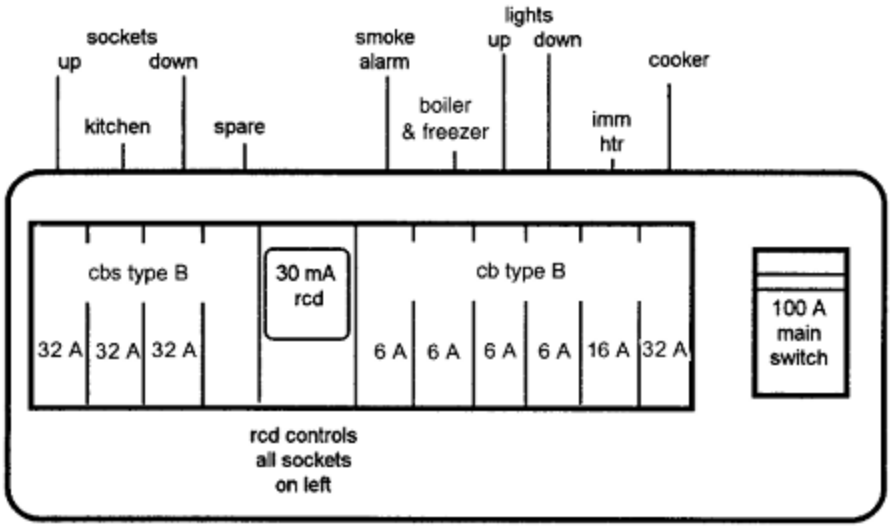


Fig. 7



476–01 amended A main switch for operation by unskilled persons, e.g. household or similar, shall interrupt both live conductors of a single phase supply.

Some domestic appliance information

Type of circuit single-phase 230 V 1 ph + N or 1 ph + N + PE	c. s. a. of the conductors	Maximum power	Protective device	
Fixed lighting	1.5 mm² (2.5 mm²)	2,300 W	Circuit-breaker Fuse	16 A 10 A
10/16 A	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Individual-load circuits				
Water heater	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Dish-washing machine	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Clothes-washing machine	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Cooker or hotplate (1)	6 mm² (10 mm²)	7,300 W	Circuit-breaker Fuse	40 A 32 A
Electric space heater	1.5 mm² (2.5 mm²)	2,300 W	Circuit-breaker Fuse	16 A 10 A